Sea ice reduction in the Arctic Ocean: its impact on biogeochemical cycles

Arctic Challenge for Sustainability

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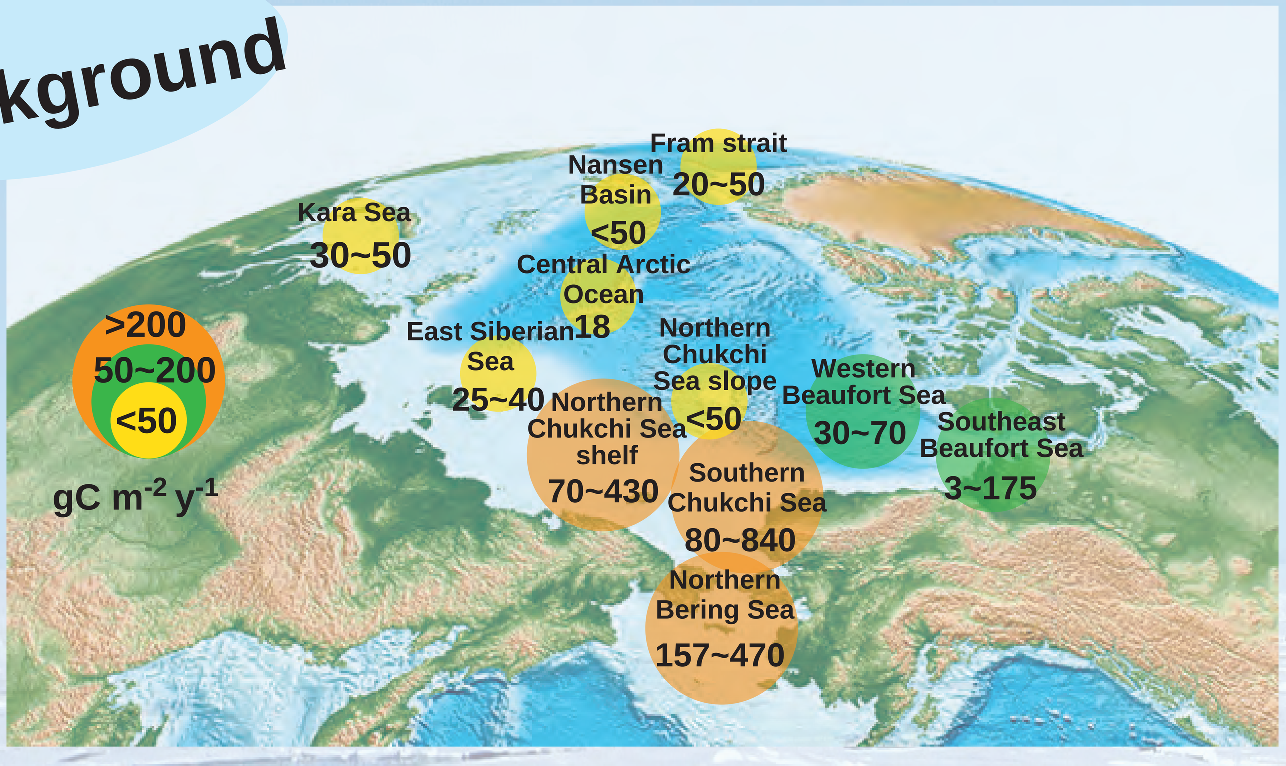
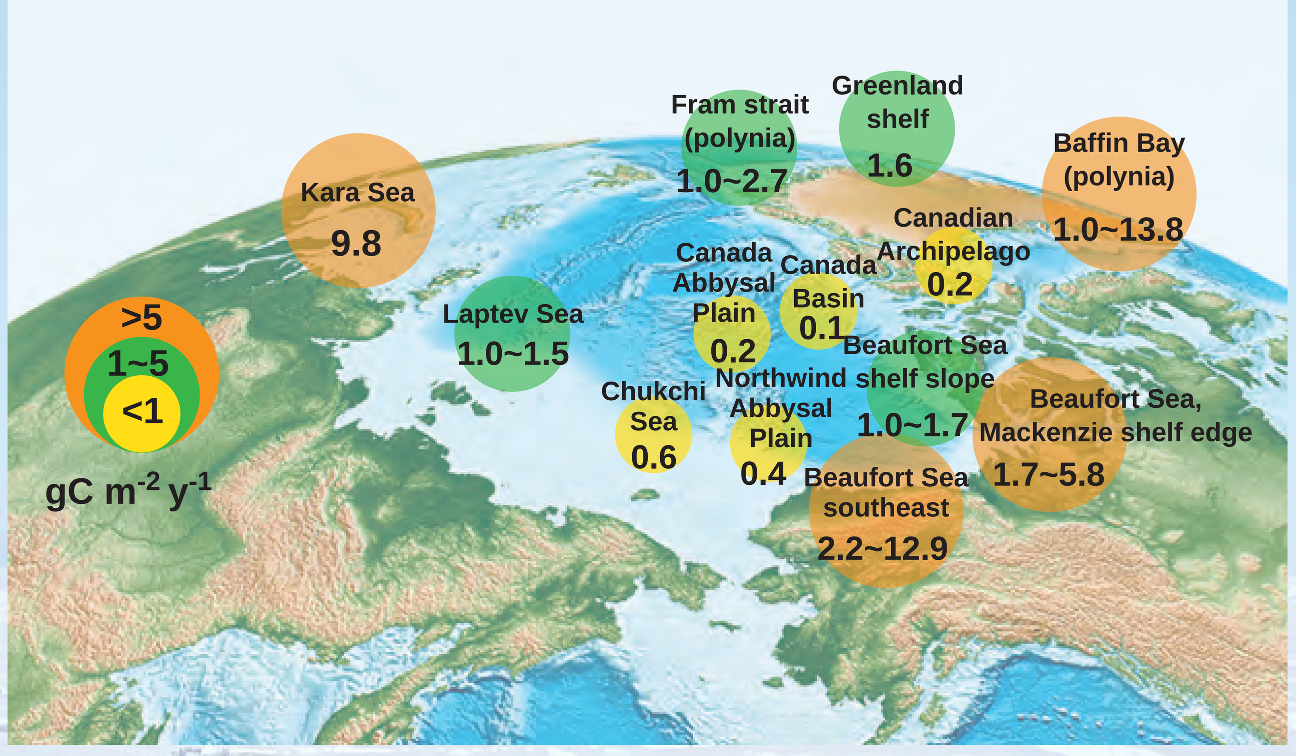
Sea ice reduction in the Arctic Ocean, has the potential to cause multiple environmental stresses, such as warming, acidification, and strengthened stratification of the ocean. We focus on the western Arctic Ocean, which very importantly, has a higher rate of primary production than any other area of the Arctic Ocean owing to the supply of nutrient-rich Pacific water. The impact of the current reduction of sea ice on marine biogeochemical cycles there, including lower-trophic-level organisms has been investigated. We would like to identify the key mechanism of changes in the biogeochemical cycles, based on observations, and model simulations to understand the responses of low trophic level marine organisms on environmental changes associated with sea ice reduction.

Background

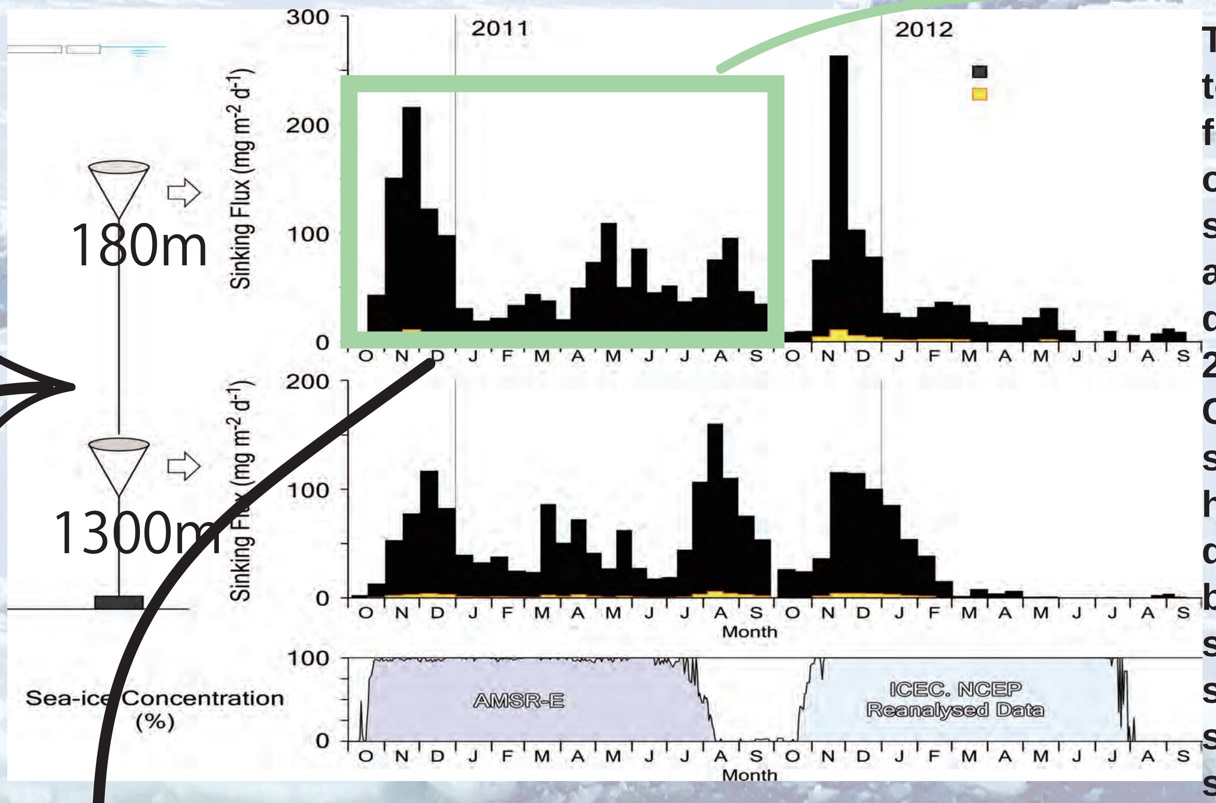


Primary production (gC m-2 y-1) estimated by in-situ observation, sediment trap mooring systems, satellite, and model simulation at various locations in the Arctic Ocean (Harada, 2016, Global Planet. Change, 136, 1-17)

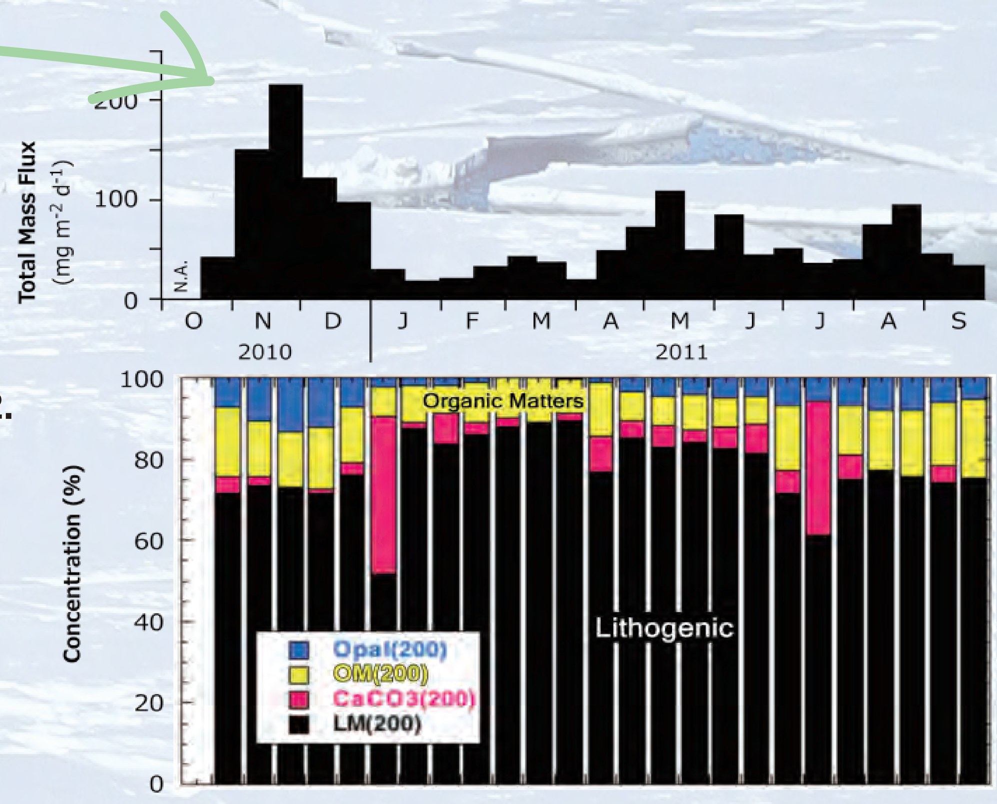


The Particulate organic carbon fluxes (g C m-2 y-1) estimated by sediment trap mooring systems in the Arctic Ocean (Harada, 2016).

Observation

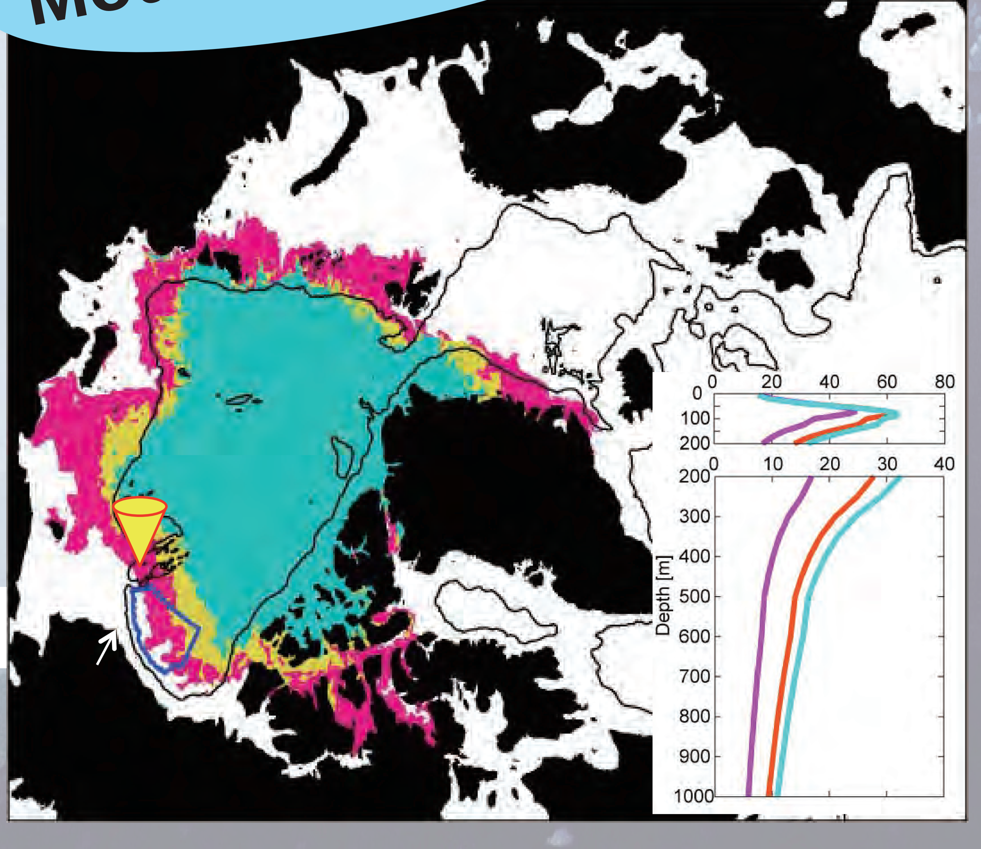


Time-series total mass fluxes observed by sediment trap at St. NAP during Oct 2010-Sep 2012. Clear seasonaity, high flux during the beginning of sea-ice and summer seasons was shown.



Most dominant component is lithogenic particles. During the Oct-Dec 2010 and Aug-Sep 2011, org C. and opal contents are high and major biogenic component is diatom.

Model&Mechanism



Model estimated sea ice covering on Oct 1 in the (yellow) 2010M, (pink) Ice2.0, and (blue) Ice0.5 cases. Black contours represent 1km isobaths. Yellow cone is St. NAP. The inset profile shows the vertical profile of Nov mean PON flux in each case (μmol-N m-2 d-1). The average region is the southwestern Canada Basin outlined by a blue (Watanabe et al., 2014 Nat.Com., doi.org/10.1038/ncomms4950).

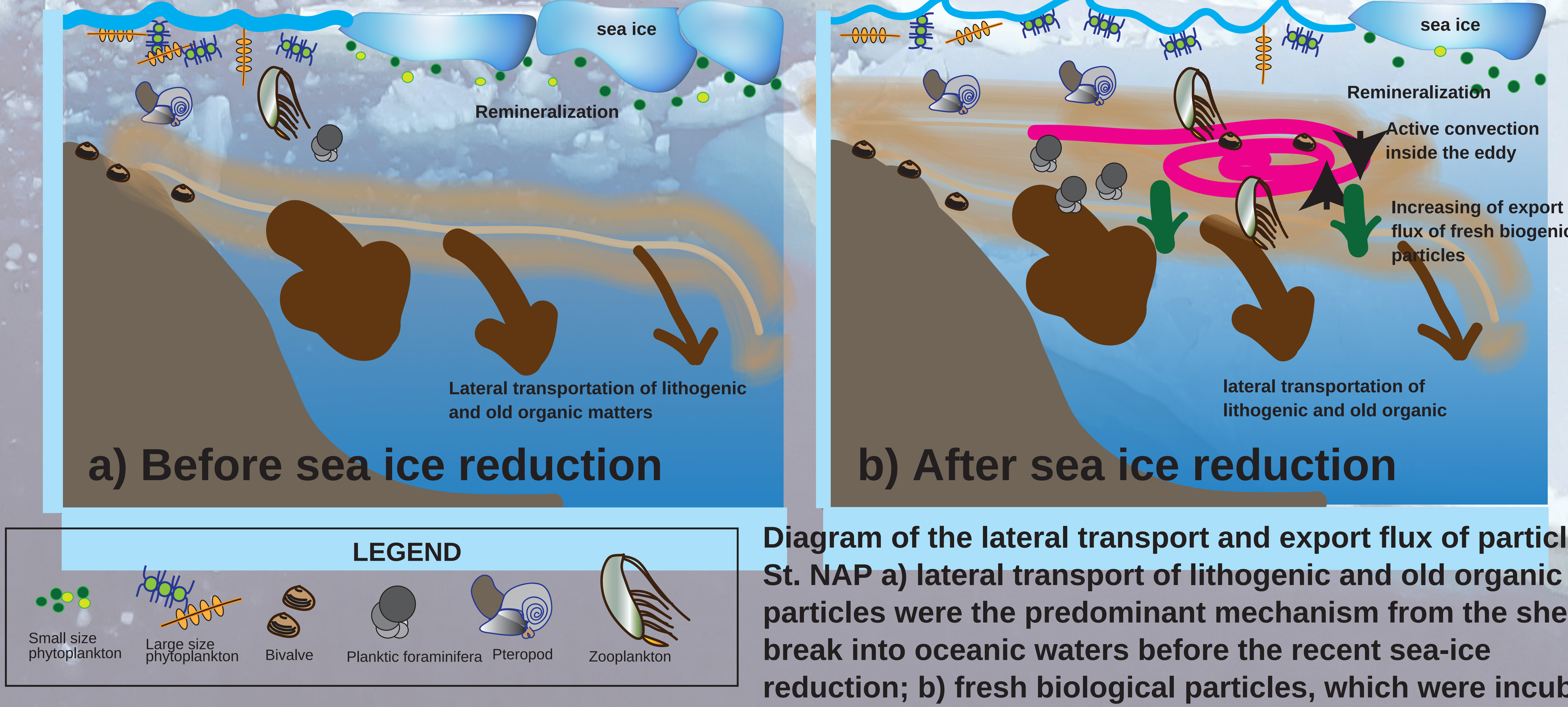
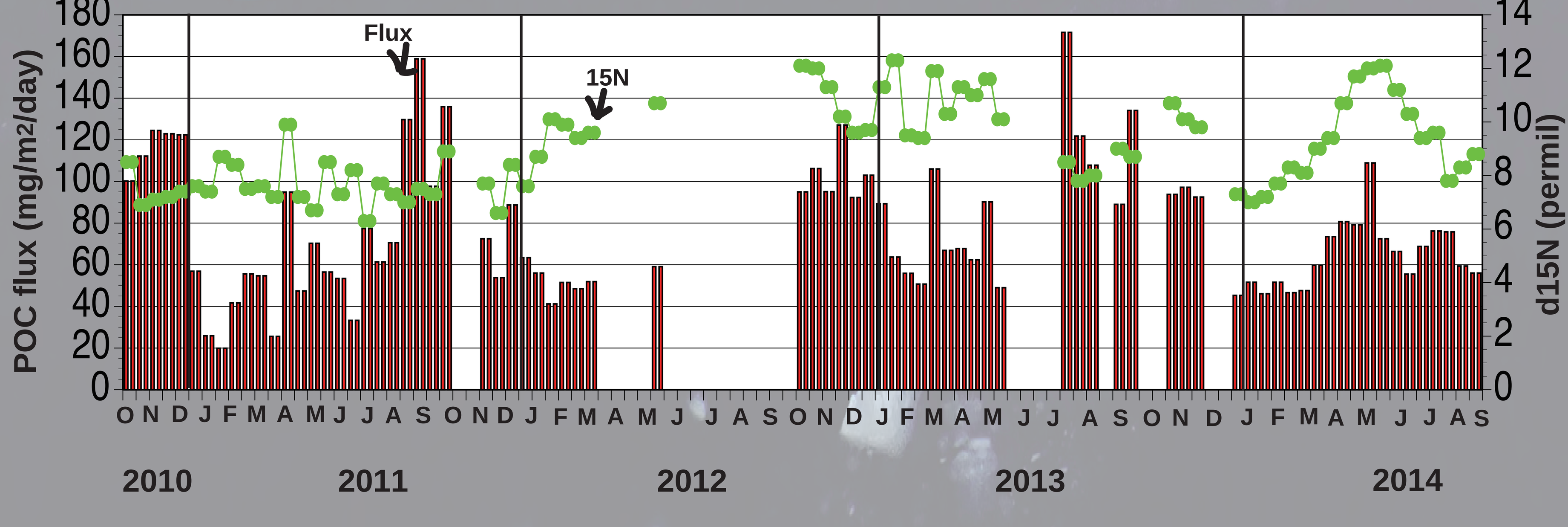


Diagram of the lateral transport and export flux of particles at St. NAP a) lateral transport of lithogenic and old organic particles were the predominant mechanism from the shelf break into oceanic waters before the recent sea-ice reduction; b) fresh biological particles, which were incubated inside the eddy and eddy induced biogenic particles that contributed to enhancement of the biological pump in the Arctic Ocean (Harada, 2016).

Latest time-series data



The POC flux collected at St.NAP from Oct 2010 to Sep 2014. The characteristics of high flux in summer and the beginning of fall seasons shown in 2010-2011 are also shown after 2012, too. Major biogenic component was Fossula antarctica and resting spore of diatome in summer and the beginning of fall season, respectively (Onodera et al., 2015, Biogeosci., 12, 1373-1385). POC flux dropped in 2012 and 2014 implying that the oligotrophic water originating from the central Canada Basin causes the suppression. A physical oceanographic model demonstrated that oligotrophic surface water from Beaufort Gyre was supplied to St.NAP from Dec 2011 to the early half of 2012 (Onodera et al., 2015). The similar phenomenone might happen in 2014.

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